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Thank you very much. It's a great privilege to be here. The title of my talk is a question "Will crop biotechnology aggravate or alleviate the impact of agriculture on the environment?" And for the first part of my talk I really want to set the scene about the kinds of technologies that are involved in the assessment process. Over the last 20 years or so we have learned how to isolate genes from different kinds of organisms, and to insert them into most of our crop plants. These give us different types of opportunities for developing novel crops but also responsibilities to manage that development. In a sense, the progress in GM crops has got caught up in a debate and may, to some extent, have catalysed that debate about agriculture and the environment.

So I want to say briefly something about what genetic modification is and to put it into context, to talk briefly about conventional breeding, then deal with some of the questions that are asked in the safety assessment process, and then deal with the question of my title, "Will GM crops aggravate or alleviate the impact of agriculture on the environment?" I will then finish with a few conclusions. Conventional plant breeding involves moving genes into crops by pollination, so we take genes from related plant species. It's a bit more complicated than that and I will come back to that in a moment, but that's the essence of it. GM plant breeding allows us to isolate genes from different classes of organisms and to insert them into crop plants and because we can take genes from different organisms, it gives us a much wider choice of genes to work with. Genetic modification is one of the tools in the plant breeder's toolbox. It is unlikely to ever replace conventional plant breeding. Conventional and GM methods are complimentary to each other and, again, all part of the series of tools available to the plant breeder. GM is not the solution to feeding the world, it is one tool in the toolbox. Feeding the world will require hard political, social, and agricultural decisions about the use of land, resources, skills, technology and probably, and ultimately about birth control. It is not the same as conventional plant breeding. There is the potential to produce some novel kinds of plant and because of that there is a requirement to go through an additional set of assessments and safety regulations.

But having said that, it is vitally important that we draw on the experience of conventional plant breeding over the last 80 - 100 years. It is possible in conventional plant breeding to introduce toxins or make crops more weedy. For example, we can hybridise wild potatoes with a cultivated potato. Some wild potato have toxins similar to those in deadly nightshade. It is perfectly possible to transfer gene toxins in conventional breeding. People ask if it isn't innately more dangerous, more unpredictable, to insert a toxin from a bacterium, compared with normal breeding methods from a related species. Well my personal feeling about that is that I feel no more comfortable about the idea of a nightshade toxin in a potato, than a bacterial toxin. We need to identify them, eliminate them and prevent them from entering the food chain, whatever their source.

Conventional plant breeding is, as I said, essentially moving genes by pollenisation but there are is now a battery of other tests which are now classed as conventional. In many respects GM is more precise than conventional plant breeding. Now that doesn't mean we know everything, there are questions, there are uncertainties. However, in many respects when you insert one gene into a plant that has 80 thousand genes you

can ask very detailed questions about the effect of those particular genes. Mutation breeding is widely used, or has over the last 80 years been widely used, in conventional plant breeding. In its simplest form this involves taking a bag of seeds, exposing them to irradiation or chemical mutagents, forcing random genetic changes. We have no control over the nature, the type of genetic change, but this, considering all those uncertainties, has been remarkably successful. Much of what we buy in our supermarkets, particularly cereals, if you trace them back in their plant breeding pedigrees, you will find inducedment to mutations back there somewhere. Conventional plant breeding also involves growing cells like a soup of cells and applying selection pressure in these cell cultures, and with these methods novel kinds of herbicide tolerantsces have been selected. Again we are still talking about conventional breeding. Wide hybridisation is possible by culturing embryos, and with embryo rescue we can produce hybrids between plant species that would not hybridise in nature. So we are moving genes across these sexual barriers between non-compatible plant species.

All of this conventional plant breeding, with all of its uncertainties, has come to rely on very careful testing, analysis and selection, to eliminate plants that have undesirable characters. It is vitally important that we draw on all of that experience, 80 years or so, in the evaluation of GM crops. Because we can move genes into crops from different kinds of organisms there is international agreement that we need an extra tier of assessment and of regulation, and in this process of safety assessment we ask a series of questions. Essentially, how does the modification change the crop, is there evidence of toxicity , allergienicity, weediness, changes and ininvasiveness in natural habitats? What about non-target effects, effects on friendly organisms? What about the possibility and the effect of gene transfer like pollination from GM crops to other plants species and other crops?

Over the last 10-15 years there have been quite a lot of experiments to try to make this safety assessment more scientifically informed. This was a series of experiments that we did in collaboration with INRA in France to measure the distance of pollination in oilseed rape. So, in the centre of this field plot, we had GM plants and we were able to measure how far the pollen went, how much pollination there was at different distances. We have also done work on sexual compatibility between various crops and related species. There are studies to look at the effect, at the potential effect from gene movement into wild populations. I think Rosie Hails will touch on this. Essentially, asking the question if a virus resistant gene, that has been put into a crop, moves into a wild Bbrassica population, what effect will it have? In doing that, you have to ask questions about those wild populations and the dynamics.

The assessment process that I have talked about deals principally with direct effects of GM crops. There is increasing interest in what are called indirect effects and this is in line with changes in the European directive, which governs all of the 15 member states within the European Union. There is now a requirement, (the dDirective was passed in March), to ask questions about changes in agronomy, changes in agricultural practice, which may be associated with the introduction of particular GM crops. Now the history of this, and this is nothing to do with GM crops for the moment, is that over the past 30 years there has been a decline in bird species. There is some dispute and argument about the nature of that, and what the forces there were

to create it, and I think both Rosie and Andrew after me will be touching on this in more detail.

These changes have been associated with changes in agricultural practices, the removal of hedges, trees and ditches, winter sowing instead of spring sowing of crops, improved pest disease and weed control. The effect of those changes has left fewer leftovers, seeds, debris, a divers ity of different plant species in the agriculture environment that are able to support a diversity of food chains. One important point to mention, which is clearly relevant to the UK agricultural scene, is that in the UK over 70% of our land area is farmed in some way, so whatever we do in agriculture has the potential to influence the environment. This compares within Canada to a with a figure of about 8%, in the States of about 50%.

In trying to measure and estimate the impact of GM crops on wildlife farmland biodiversity, the farmlandscale trials were initiated in 1999. So this is taking three GM crops (glufosinolate tolerant maize, oilseed rape and glyphosate tolerant sugarbeet) and asking questions about the potential impact on wildlife of the change in agronomy that would be brought about by the use of these particular types of crops. The aim of these trials is to assess the frequency of indicator species as a measure of farmland by biodiversity, and these include seeds in the soil, plant species, slugs, insects and so on. Now I am not involved in any of the science and I know that there are people here who are, but I have been involved in some of the discussions about how we handle, how we use these kinds of data. The result of those experiments will be available in 2002/2003. It's raised quite a lot of important questions. Now I just want to go through a few of the questions which seem important to me.

The first one is that it is relatively easy to test for statistical significance but much more challenging to determine what is ecologically significant. If you imagine in the field trials, half of the experimental area is GM oilseed rape and the other half is non-GM oilseed rape, a variety the farmer would use if he wasn't growing GM. So we have to ask direct questions about the frequency of indicator species in these two halves. Statistical analysis is essentially a mathematical comparison of frequencies within the two halves. It is fairly straightforward. But how do we decide what is ecologically significant or environmentally significant?

The second point is that there have interestingly been very few similar kinds of experiments assessing the environmental impact of particular conventionally bred varieties. So Here we are not talking about broad trends in agriculture. We are asking what particular impact will this particular variety have on wildlife by biodiversity so what baselines do we have for saying this impact is acceptable and that is not? Another interesting reflection is that GM crops are assessed very closely in minute detail for their impact on the environment, but there are very few comparable kinds of assessments for conventionally bred crops. It is possible to produce herbicide tolerant varieties by genetic modification or by conventional means. We ask all kinds of detailed questions about GM but very few comparable ones about conventional crops. That to my mind is illogical. The trials have been contentious in the sense of the possibility of gene flow, mainly between the GM crops and organic farms. I think this raises an important question about accommodating different forms of agriculture, accommodating organic, GM, conventional and integrated systems. We have to find

some way of doing that. So I think these kinds of experiments will raise as many questions about conventional agriculture as they will about genetic modification.

Turning to the question in the title, I believe that GM crops are innately no more or less damaging to the environment than conventional ones. The challenge is how we use genetic modification, how we develop crops and how we use them. Agriculture will always have a significant impact on the environment. I said that over 70% of our land area is in some form of agriculture. To some extent there will always be a degree of trade off between maximising crop productivity and maximising wildlife. It's not quite as simple as that, but that's the essence of the challenge before us. I believe that GM crops will aggravate, will impact or have the potential to impact adversely if they drive agriculture further towards monoculture and the clinical control of all aspects of the agriculture environment. If there is poorly targeted broad spectrum pest and disease resistance expressinged throughout the plant (when you make a GM plant you have some control over where the particular genes are expressed) and if they are expressed throughout the plant then there is the increased potential problem of these non-target effects on organisms within the environment.

If there is tight targeted control over weed and feral plants throughout the growing season, they GM crops have the potential to alleviate the impact on the environment if they are incorporated into a rotation with attention to soil fertility, organic matter, hedgerows and wildlife refuge areas. We can target genetic control of pest and diseases by having genes expressed in the leaf or wherever the pest attacks the plant. Also, one of the exciting things about the science is that it is becoming possible to have very specific expression of genes, even wound inducing expression where if an aphid attacks a plant then there can be a response against that so it is very targeted. I think that is a challenge for the scientific community. If there is reduced dependence on certain chemicals, for example, if we insert virus resistance then it is likely not to be necessary to control the aphid, or whatever is the vector, and there is some evidence where this has been tried there has been an increase in populations of ladybirds or beetles that feed on them. So that is the challenge for those of us involved in research and development. So in conclusion, we cannot uninvent biotechnology, there are 44 million hectares around the world. We are right to be cautious when we reflect on some of the effects of pesticides and nitrates in water and so on. We need to have an informed debate about our vision for agriculture in the environment and ways to achieve it. One of the features of GM is that potentially changes can happen relatively quickly. Once there is a breakthrough we know how to do something, then it is possible to develop that character in a range of crops. The safety assessment process is done on a case-by-case basis, so the different products come to the table and we assess them. The primary weakness is that it is not particularly visionary. If you imagine something like eight different herbicide tolerance genes available. Is it acceptable to consider all eight, how do we make the decision?

There are some really challenging questions. The challenge is how we orchestrate these changes. There will be a diversity of crops coming forward and we will learn about some of those at this meeting. How do we manage it in the future? I believe it cannot be left simply to market forces, which is a very blunt instrument for deciding the way forward. We need to think and work towards, in my view, for the stepwise introduction of GM crops in Europe and environmental monitoring. There is a requirement now within the European Union, under the new directive that has just

been passed, that when you get permission to commercialise a crop you have a period of monitoring and after that period it is reassessed, which I think that is sensible. My hope is that in the discussion here and the debate generally, there will be much less heat about this technology or that technology and much more light about the future shape of agriculture in the next 20 years and beyond.

Thank you very much.